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(54) **BORING APPARATUS AND METHOD**

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Description

BACKGROUND OF THE INVENTION

[0001] This disclosure relates to a boring apparatus and method. More particularly, but not by way of limitation, this invention relates to a drill bit and a method of boring wells.

[0002] Drill bits have been used for boring subterranean wells. In the boring of a wellbore, the operator seeks to drill the well efficiently, safely, and economically. Drill bits are required to drill straight wells, deviated wells, horizontal wells, multilaterals, etc. Various drill bits have been proposed through the years, including roller-cone bits and polycrystalline diamond compact bits.

[0003] The following documents may be useful in understanding the background to the present disclosure. US 1 746 455 discloses a rotary drilling bit of the bladed type with a pilot blade extending below other blades attached to a body, and having means for raising and lowering the body during the rotation of the bit. US 2 727 215 discloses a rotary rock drilling tool comprising a tubular upper bit section connectable to a drill pipe, a tubular lower bit section, and a pilot bit projecting slightly below cutting edges of the tool. Whilst drilling, when the tool meets hard material resisting rotation of the pilot bit, a cam mechanism actuates a movement of the main portion of the tool to effect a heavy impact upon the pilot bit to crush hard material. WO 2009/111887 discloses a drilling accelerator that is driven from a rotational drive to generate percussive axial motion on a drill bit. US 3 375 889 A discloses a rotary drill bit mounted on a non-rotating pipe string, which rotary drill bit includes a central cutting portion, such that there are both central and outer cutting portions. The central and outer cutting portions are connected and driven by drilling mud circulation through turbine means in contra-rotation at constant relative speeds.

SUMMARY OF THE INVENTION

[0004] An apparatus for boring a wellbore as defined in claim 1 is disclosed. The apparatus may be connected to a workstring concentrically positioned in the well bore.

[0005] The workstring may contain a mud motor for delivering rotational force. The apparatus may further include a retainer operatively associated with the pilot bit for retaining the pilot bit within the inner cavity. The workstring may be a tubular drill string or a coiled tubing string. Each of the rolling elements in the apparatus of claim 1 may include a spherical outer surface. The apparatus may include three or more rolling elements, with each of the rolling elements in contact with two adjacent rolling elements. The apparatus may include two or more rolling elements and a guide member, which is disposed between the first and second radial cam surfaces for retaining the rolling elements in a fixed position relative to one another.

[0006] A method of boring a wellbore as defined in claim 5 is also disclosed. In one form, the first radial cam surface comprises an inclined portion and an upstanding portion, and the second radial cam surface comprises an inclined portion and an upstanding portion. The workstring may contain a mud motor for delivering a rotational force. The workstring may be a tubular drill string, production string, or a coiled tubing string. In the method a pilot bit of the bit apparatus may be rotated due to frictional forces associated with the rotation of the bit body, with a rotation rate of the pilot bit being lower than a rotation rate of the bit body. The bit apparatus includes one or more rolling elements disposed between and in contact with the first and second radial cam surfaces, and the method includes impacting the second radial cam surface with the first radial cam surface through the rolling elements. Each of the rolling elements may include a spherical outer surface. Further features of the apparatus are illustrated in the accompanying drawings which include figures provided for reference purposes to aid understanding of the disclosure but not in accordance with the invention, and thus are marked "for reference purposes".

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIGURE 1 is a sectional view a bit disclosed in this specification for reference purposes (not in accordance with the invention).

FIGURE 2 is a perspective view of one form of a cam surface, shown on a pilot bit for reference purposes (not in accordance with the invention).

FIGURE 3 is an enlarged, partial sectional view of the area marked as "A" in FIGURE 1 which depicts the radial cam surface within the bit.

FIGURE 4 is a perspective view of the pilot bit seen in FIGURE 1 for reference purposes (not in accordance with the invention).

FIGURE 5 is a sectional view of a bit disclosed in this specification for reference purposes (not in accordance with the invention).

FIGURE 6 is a perspective view of the pilot bit seen in FIGURE 5.

FIGURE 7 is a cross-sectional view of the bit of FIGURE 1 taken along line A-A.

FIGURE 8 is a cross-sectional view of an embodiment of the bit disclosed in this specification.

FIGURE 9A is a perspective view of a radial cam surface of the bit shown in FIGURE 8.

FIGURE 9B is a schematic view of the circumferential profile of the radial cam surface shown in FIGURE 9A.

FIGURE 9C is a perspective view of an alternate radial cam surface.

FIGURE 10 is a cross-sectional view of a bit disclosed in this specification.

FIGURE 11 is an enlarged, partial sectional view of the area marked as "B" in FIGURE 10.

FIGURE 12 is a schematic representation of a workstring extending from a rig, with the workstring being placed concentrically within a wellbore.

FIGURE 13 is a cross-sectional view of an apparatus for applying axial movement with a rotating member.

FIGURE 14A is a cross-sectional view of the apparatus taken along line A-A in FIGURE 13.

FIGURE 14B is an alternate cross-sectional view of the apparatus taken along line A-A in FIGURE 13.

FIGURE 14C is another alternate cross-sectional view of the apparatus taken along line A-A in FIGURE 13.

FIGURE 14D is yet another alternate cross-sectional view of the apparatus taken along line A-A in FIGURE 13.

FIGURE 15 is a cross-sectional view of the apparatus of FIGURE 13 including a guide member.

FIGURE 16A is a cross-sectional view of the apparatus taken along line B-B in FIGURE 15.

FIGURE 16B is an alternate cross-sectional view of the apparatus taken along line B-B in FIGURE 15.

FIGURE 16C is another alternate cross-sectional view of the apparatus taken along line B-B in FIGURE 15.

FIGURE 16D is yet another alternate cross-sectional view of the apparatus taken along line B-B in FIGURE 15.

DETAILED DESCRIPTION OF THE DRAWINGS

[0008] Fig. 1 is a sectional view of a bit **2** disclosed in this specification for reference purposes to aid understanding of a bit assembly including a pilot bit (not in accordance with the invention). The bit 2 includes a first end **4** having an outer diameter that contains external thread means **6,** wherein the external thread means 6 will connect to a workstring (not seen in this view). Bit 2 may be any tool that is capable of drilling a bore into a rock formation, such as a drag bit, a roller cone bit, a chisel-type bit, or a mill. As appreciated by those of ordinary skill in the art, the workstring may include a bottom hole assembly that includes measurement while drilling instruments, mud motor means, and drill collars (note that this list is illustrative). The external thread means 6 extends to a radial shoulder **8** which in turn extends to the outer conical surface **10.** As seen in Fig. 1, the outer conical surface 10 extends to a plurality of blades, including blades **12** and **14.** The bit 2, and in particular the blades 12, 14, contain cutting members for drilling and crushing subterranean rock as appreciated by those of ordinary skill in the art. In one form, the blades 12, 14 comprise leg portions upon which the cutting members can be connected. For instance, Fig. 1 depicts cutting members **16, 18, 20, 22** connected to the distal ends **23** (also referred to as the working face 23) of the leg portions of the blades 12, 14. Hence, the cutting members 16, 18, 20, 22 are contained on the working face 23 of the bit 2.

[0009] The bit 2 also contains a radially flat top surface **24** which extends radially inward to the inner diameter portion **26.** The inner diameter portion 26 stretches to the opening, seen generally at **28.** Opening 28 is sometimes referred to as an inner cavity. The opening 28 has an internal profile **30,** wherein the profile 30 contains a first radial cam surface which will be described with reference to Fig. 2. The opening 28 extends to the bottom of the bit 2. As seen in Fig. 1, disposed within the opening 28 is the pilot bit **32** (the pilot bit 32 may be referred to as the protuberance 32). Pilot bit 32 may, but need not, extend beyond working face 23 of bit 2. The pilot bit 32 has a first end (generally seen at **34**) and a second end (generally seen at **36**). The first end 34 contains a second radial cam surface which will be described with reference to Fig. 3. It should be noted that the first and second radial cam surfaces cooperate together as will be more fully explained later in the disclosure.

[0010] As seen in Fig. 1, the opening 28 further includes the increased diameter circumference area **38** which is adapted for placement of retainer **40** therein for retaining pilot bit 32 within opening 28. Retainer 40 may be ball members as shown. Alternatively, retainer 40 may be a pin, set screw, or other similar mechanism disposed at least partially within opening 28 for retaining pilot bit 32 within opening 28. Any number of retainers 40 may be included. More specifically, the pilot bit 32 contains a first outer diameter surface **42** which stretches to the chamfered surface **44** which in turn extends to the second outer diameter surface **46,** then to the chamfered surface **48,** then to third outer diameter surface **50.** In the pilot bit depicted in Fig. 1 (not claimed), the third outer diameter surface 50 extends to the chiseled profile surface, seen generally at **52,** with the chiseled profile surface 52 having a beveled end **54** for contacting the subterranean rock. In contrast to the claimed invention, the center line **56** runs through the inner diameter portion 26 of the bit 2 as well as through the beveled end 54 of the pilot bit 32. The ball bearing members 40 allow the rotation of the bit 2 as well as the rotation of the pilot bit 32. In one form, ball bearing members 40 allow bit 2 and pilot bit 32 to rotate at different speeds such that the bit 2 may have a first rotation rate, measured in revolutions per minute (RPM), while the pilot bit 32 may have a second rotation rate, also measured in RPM. First and third outer diameter surfaces 42 and 50 of pilot bit 32 may function as radial bearings, along with the inner surfaces of opening 28 of bit 2.

[0011] Referring now to Fig. 2, a perspective view of one form of the second radial cam surface **60** on the pilot bit 32 will now be described. It should be noted that like numbers refer to like components in the various drawings. Fig. 2 depicts the outer diameter surface 42 as well as the outer diameter surface 50, with the outer diameter surface 50 extending to the chiseled profile surface 52. In one form, the second radial cam surface 60 contains three ramps, namely ramps **62, 64, 66.** The ramps 62, 64, and 66 will cooperate with the internal profile 30 to deliver the hammering force as will be more fully explained below. The ramp 66 contains an upstanding portion **68,** an inclined portion **70** and a flat portion **72** that is intermediate of the inclined portion 70 and upstanding portion 70. The ramps 62, 64, and 66 are of similar construction. The radially flat area **74a, 74b, 74c** will be the area that the two radial cams will impact during the hammering action. In other words, the radially flat areas 74a, 74b, 74c receive the hammering force and not the ramp surfaces.

[0012] Referring specifically to Fig. 3, which is an enlarged partial sectional view of the circled area marked "A" in Fig. 1 will now be described. Fig. 3 depicts the first radial cam surface **80** on the internal profile 30 of bit 2. Fig. 3 shows the inclined portion **82** which stretches to the upstanding portion **84** that then levels off to a flat portion **86.** The radially flat area is depicted at **88.** The inclined portion 82, upstanding portion 84, the flat portion 86, and the radially flat area 88 are reciprocal with the second radial cam surface 60 previously described. The second radial cam surface 60 will cooperate with first radial cam surface 80 in order to generate a hammer force as per the teachings of this disclosure. Internal profile 30 engages and cooperates with second radial cam surface 60 so that as bit 2 rotates relative to pilot bit 32 (i.e., pilot bit 32 does not rotate or pilot bit 32 rotates at a different rotational rate than bit 2), flat portion 86 of internal profile 30 slides up inclined portion 70, across flat portion 72, over upstanding portion 68, and onto flat area 74b of second radial cam surface 60. As flat portion 86 falls onto flat area 74b of second radial cam surface 60, a percussive force will be generated in an axial direction through bit 2 and pilot bit 32 for assisting in drilling through a subterranean formation. In one form, the second radial cam surface 60 is an anvil member and the first radial cam surface 80 is a hammer member.

[0013] Fig. 4 is a perspective view of the pilot bit member shown in Fig. 1, namely pilot bit 32. As seen in Fig. 4, the outer diameter surface 50 extends to the first concave surface **90** as well as the second concave surface **92** which in turn extends to the beveled end 54. Hence, as drilling progresses, the beveled end 54 may contact the subterranean rock which in turn will be crushed and chiseled.

[0014] Fig. 5 is a sectional view of a modified bit **94,** with Fig. 5 depicting the inclusion ofa pilot bit **96** containing an eccentric conical surface **98** which is a feature of the claimed invention. The bit 94 is the same as the bit 2 depicted in Fig. 1 except for the pilot bit 96 which differs as follows. As seen in Fig. 5, the center line **100** through the center of the bit 94 is offset from the apex **102** of the cone portion **104** of pilot bit 96. The center line **106** of the cone portion 104 is offset from the center line 100 of the bit 94 thereby forming an eccentric conical surface 104. Because of this offset (i.e., the eccentric distance), a higher torque is required to rotate pilot bit 96, which in turn requires a higher friction between the radial cam surfaces of bit 94 and pilot bit 96 in order to rotate pilot bit 96. With a greater eccentric distance of apex 102, a higher torque will be required to rotate pilot bit 96. Thus, the eccentric distance produces a higher difference between the rotational rate of bit 2 and the rotational rate of pilot bit 96 (i.e., a higher relative rotation), thereby increasing the frequency of impacts created by the interaction of the radial cam surfaces.

[0015] Referring now to Fig. 6, a perspective view of the pilot bit member 96 seen in Fig. 5 will now be described. The pilot bit 96 contains at the distal end the cone portion 104 that leads to the apex 102. The cone portion 104 is eccentrically positioned which forms a radial area **108.** The cone portion 104 may be integrally formed on the body of the pilot bit 96 or may be attached such as by welding.

[0016] Fig. 7 is a cross-sectional view of the bit 2 of Fig. 1 taken along line 7-7. Hence, the pilot bit 32 is shown along with the ball bearing members, such as member 40, with the ball bearing member 40 being positioned in the increased diameter circumference area 38. Also shown are the blades 12, 14 along with blade **109.** Fig. 7 shows how the bit 2 may rotate in a clockwise direction **110** relative to pilot bit 32. While bit 2 is configured to rotate, pilot bit 32 is not designed to rotate. Accordingly, pilot bit 32 may be a non-rotating member. However, frictional forces may cause pilot bit 32 to rotate. In that case, pilot bit 32 will rotate at a different rotational rate than bit 2.

[0017] Fig. 8 illustrates an embodiment of bit **113.** Except as otherwise noted, bit 113 is the same as bit 2. Bit 113 includes blades **114** and **115.** Bit 113 also includes inner cavity **116** extending at least from radial cam surface **117** to radial surface **118.** Pilot bit **119** includes shaft portion **120** extending from upper portion **121** to cone portion **122.** Apex **123** of cone portion 122 is offset from center line **124** of bit 113. Upper portion 121 includes radial cam surface **125** and radial shoulder **126.** Radial surface 118 of bit 113 retains upper portion 121 of pilot bit 119 within inner cavity 116.

[0018] Bit 113 further includes rolling elements **127** and **128** positioned between and in contact with radial cam surfaces 117 and 125. Rolling elements 127, 128 may also be referred to herein as rotating elements. In one preferred embodiment, rolling elements 127, 128 are spherical members such as stainless steel ball bearings or ceramic balls. In this embodiment, each spherical member may have a diameter that is approximately equal to one-half of the inner diameter of inner cavity 116, such that the spherical members are in contact with one another. It should be understood that bit 113 may include any number of rolling elements. The number of rolling elements included may be equal to the number of high points or ramps on each of radial cam surfaces 117 and 125. Each of the rolling elements may be the same size.

[0019] Rolling elements 127, 128 may be free to move between radial cam surfaces 117 and 125 as bit 113 rotates relative to pilot bit 119. In one embodiment, rolling elements 127, 128 may move in a circular path on radial cam surface 125 as bit 113 rotates relative to pilot bit 119. This movement of rolling elements 127, 128 over radial cam surfaces 117 and 125 may cause axial movement of pilot bit 119 relative to bit 113. Use of rolling elements 127, 128 allows for less of a direct impact between radial cam surfaces 117 and 125 of bit 113 and pilot bit 119, which may increase the life of bit 113 and pilot bit 119.

[0020] Fig. 9A illustrates a radial cam surface 125. This radial cam surface 125 includes a series of surfaces, namely surfaces **125a, 125b, 125c, 125d, 125e, 125f, 125g, 125h, 125i, 125j, 125k, 125l.** Several of these surfaces may have a rising or falling slope such that radial cam surface 125 has a multiple segmented radial face. Fig. 9B is a circumferential profile view of radial cam surface 125 shown in Fig. 9A. Fig. 9C illustrates another form of radial cam surface 125. In this form, radial cam surface 125 includes cam low side **126a** and cam high side **126b.** The profile of this radial cam surface 125 may be a smoother waveform such as a sinusoidal waveform. It should be noted that the radial cam surfaces 125 shown in Figs. 9A and 9C may both be referred to as an undulating profile. Radial cam surface 117 of bit 113 may have a reciprocal shape to radial cam surface 125. Alternatively, one of radial cam surfaces 117 and 125 may be a flat radial surface.

[0021] Fig. 10 is a sectional view of a yet another form of bit **130.** Except as otherwise noted, bit 130 is the same as bit 2. Bit 130 includes blades **132** and **134.** Bit 130 also includes inner cavity **136** leading from radial cam surface **138** and hammer surface **140** to working face **142.** Radial cam surface 138 and hammer surface 140 may be axially separated by a distance. Pilot bit **144** may be disposed within inner cavity 136 of bit 130. Pilot bit 144 includes first end **146** and second end **148.** First end 146 includes radial cam surface **150** and anvil surface **152.** Radial cam surface 150 and anvil surface 152 are axially separated by a distance. Radial cam surface 150 may cooperate with radial cam surface 138, and anvil surface 152 may cooperate with hammer surface 140. Second end 148 of pilot bit 144 may include a chiseled profile surface (as shown in Fig. 10 and not in accordance with the invention) or in accordance with the invention includes an eccentric conical portion of the type discussed above.

[0022] Fig. 11 is an enlarged view of the section B in Fig. 10. This view shows that when hammer surface 140 of bit 130 is in contact with anvil surface 152 of pilot bit 144, radial cam surfaces 138 and 150 are separated by the distance ΔX. As bit 130 rotates relative to pilot bit 144, radial cam surface 138 of bit 130 engages radial cam surface 150 of pilot bit 144. As explained above in connection with other forms, each high point **154** on radial cam surface 138 slides along each ramp **156** of radial cam surface 150. During this time, hammer surface 140 will separate from anvil surface 152. When each high point 154 of radial cam surface 138 slides over each high point **158** of radial cam surface 150, each high point 154 will drop over upstanding portions **160** of radial cam surface 150. This drop causes hammer surface 140 of bit 130 to impact anvil surface 152 of pilot bit 144. Because of the separation by distance ΔX, the impact force is not placed directly on radial cam surfaces radial cam surfaces 138 and 150. This arrangement will increase longevity of bit 130 and pilot bit 144 by reducing wear on radial cam surfaces 138 and 150. This embodiment in accordance with the invention also includes one or more rolling elements between radial cam surfaces 138 and 150. Where rolling elements are used, rolling element may not be in contact with both cam surfaces when hammer surface 140 contacts and impacts anvil surface 150.

[0023] Referring now to Fig. 12, a schematic representation of a workstring **230** extending from a rig **232,** with the workstring 230 being placed concentrically within a wellbore **234.** The workstring 230 will be operatively connected to a bottom hole assembly, seen generally at **236.** In the embodiment of Fig. 12, the bottom hole assembly 236 includes a mud motor means **238** for rotatively driving the bit 2. As understood by those of ordinary skill in the art, in the course of drilling a well, a drilling fluid is pumped through the workstring 230. The drilling fluid is channeled through the mud motor means thereby causing a segment of the bottom hole assembly to rotate. The rotative force is transferred to the bit 2 which will cause the bit 2 to be rotated relative to the pilot bit 32. Hence, the bit 2 is rotated so that a first rotation rate is achieved. The cutting members (e.g., cutting members 16, 18, 20, 22 shown in Fig. 1) contained on the working face 23 will also engage with the reservoir interface **240.** The beveled end 54 of the pilot bit 32 (shown in Fig. 4), the apex 102 of pilot bit 96 (shown in Fig. 6), or the apex 123 of pilot bit 119 will engage the reservoir interface 240. It should be understood that unless otherwise noted, the bits 2, 94, 113, and 130 function in the same way and pilot bits 32, 96, 119, and 144 function in the same way.

[0024] Pilot bit 32 may not rotate during boring operations. However, relative rotation of bit 2 relative to pilot bit 32 may cause pilot bit 32 to rotate due to frictional forces. Relative rotation between bit 2 and pilot bit 32 may be caused by sliding and rolling friction between bit 2 and pilot bit 32 and by friction between both members and the reservoir rock surrounding the wellbore. Bit 2 and pilot bit 32 may require different torque values to overcome the rolling friction and friction with the reservoir rock, which may cause rotation of pilot bit 32 at a different rotation rate than that of bit 2. Relative rotation may also be caused by the eccentric offset of apex 102 from the center line of bit 94 when pilot bit 96 is used. Bit 2 may rotate at a higher rotation rate or speed than pilot bit 32. For example, the bit may rotate at 80-400 RPM, while the pilot bit may rotate at 2-10 RPM. The method further includes impacting the second radial cam surface 60 against the first radial cam surface 80 so that a percussive force is delivered to the working face 23 and the pilot bit 32. In this way, the relative rotation between bit 2 and pilot bit 32 is converted into a relative axial movement between bit 2 and pilot bit 32. The cutting and crushing action of the cutting members 16, 18, 20, 22 and pilot bit 32 coupled with the hammering force will drill the wellbore.

[0025] In use, the first radial cam surface which comprises an inclined portion and upstanding portion and the second radial cam surface which comprises an inclined portion and upstanding portion that are reciprocal and cooperate to create the hammering force on the radially flat areas, such as areas 74a, 74b, 74c seen in Fig. 2. The workstring may contain a mud motor for delivering a rotational force. However, other surface rotary means may be used for imparting rotation of the workstring from the rig floor. The workstring may be selected from the group consisting of a tubular drill string, a coiled tubing string, and snubbing pipe.

[0026] Fig. 13 illustrates apparatus **302** including rotating member **304** (sometimes referred to as rotating segment) and second member **306** (sometimes referred to as second segment). Rotating member 304 and second member 306 may each be at least partially disposed within housing **308.** Rotating member 304 includes first radial surface **310.** Second member 306 includes second radial surface **312** opposing first radial surface 310. First radial surface 310 or second radial surface 312 includes a tapered surface as described above. In one embodiment, both radial surfaces 310, 312 include a tapered surface. The tapered surface may be an undulating waveform profile. It should be understood that rotating member 304 may be positioned above or below second member 306.

[0027] Apparatus 302 includes one or more rolling elements **314.** In one embodiment, apparatus 302 includes two rolling elements **314a, 314b** as shown in Fig. 13. Each rolling element may have, but is not limited to, a spherical outer surface having a diameter that is approximately equal to one-half of an inner diameter of housing 308 such that rolling elements 314a and 314b are in constant contact with one another. It should be understood that apparatus 302 includes any number of rolling elements. The number of rolling elements included in the downhole apparatus may be equal to the number of high points or ramps on each of radial surfaces 310 and 312. Each of the rolling elements may be the same size.

[0028] Rotating member 304 may rotate continuously relative to second member 306, i.e., rotating member 304 may rotate more than 360 degrees relative to second member 306. In one embodiment, second member 306 is a non-rotating member. Non-rotating member means that the member is not designed to rotate and the member is substantially non-rotating relative to the rotating member. Alternatively, second member 306 is a member rotating at a different rotation rate than rotating member 304. Rotation rate is the speed of rotation, which may be measured in units of rotation or revolutions per minute (RPM). Alternatively, second member 306 and rotating member 304 rotate in opposite directions. In all embodiments, as rotating member 304 rotates relative to second member 306, rolling elements 314 move between first and second radial surfaces 310 and 312 thereby producing an axial movement of second member 306 relative to rotating member 304. Rolling elements 314 may each move 360 degrees along a circular path relative to second radial surface 312. Rolling elements 314 may also each move 360 degrees along a circular path relative to first radial surface 310. The movement of rolling elements 314 on first and second radial surfaces 310 and 312 may occur simultaneously, such that rolling elements 314 move 360 degrees along a circular path relative to the first radial surface 310 and simultaneously move 360 degrees along a circular path relative to the second radial surface 312.

[0029] It should be understood that apparatus 302 is not limited to the directional and inclinational arrangement shown. In other words, apparatus 302 will function as long as first radial surface 310 opposes second radial surface 31 with one or more rolling elements disposed between. Apparatus 302 may be arranged in an inverted vertical position relative to the one shown in these drawings. Apparatus 302 may also be arranged in a horizontal position or any other inclinational position.

[0030] Fig. 14A is a cross-sectional view taken along line A-A in Fig. 13 showing rolling elements 314a, 314b on first radial surface 310 disposed within housing 308. Fig. 14B is an alternate cross-sectional view taken along line A-A in Fig. 13. In this figure, apparatus 302 includes three rolling elements, namely rolling elements 314a, 314b, 314c. Fig. 14C is another alternate cross-sectional view taken along line A-A in Fig. 13 showing apparatus 302 including four rolling elements, namely rolling elements 314a, 314b, 314c, 314d. Fig. 14D is yet another alternate cross-sectional view taken along line A-A in Fig. 13 showing apparatus 302 including ten rolling elements, namely rolling elements 314a, 314b, 314c, 314d, 314e, 314f, 314g, 314h, 314i, 314j. Each rolling element in Figs. 14B, 14C, and 14D may be dimensioned such that each rolling element is in contact with two adjacent rolling elements.

[0031] Fig. 15 illustrates apparatus 302 having a guide member **316** disposed between radial surfaces 310 and 312. Guide member 316 is used to contain rolling elements 314a and 314b in a fixed position relative to one another. Fig. 16A is a cross-sectional view taken along line B-B in Fig. 15 showing rolling elements 314a, 314b retained by guide member 316 on first radial surface 310 disposed within housing 308. In this arrangement, rolling elements 314a, 314b are dimensioned so that they are in constant contact with one another. Fig. 16B is an alternate cross-sectional view taken along line B-B in Fig. 15. In this configuration, apparatus 302 includes two rolling elements 314a, 314b, with the rolling elements dimensioned so that they are separated from one another. Guide member 316 retains rolling elements 314a, 314b in a fixed position relative to one another, such as 180 degrees apart. Fig. 16C is another alternate cross-sectional view taken along line B-B in Fig. 15. In this configuration, apparatus 302 includes three rolling elements 314a, 314b, 314c, with the rolling elements dimensioned so that they are separated from one another and retained in a fixed position relative to one another by guide member 316, such as 120 degrees apart. Fig. 16D is yet another alternate cross-sectional view taken along line B-B in Fig. 15. In this arrangement, apparatus 302 includes four rolling elements 314a, 314b, 314c, 314d, with the rolling elements dimensioned so that they are separated from one another and retained in a fixed position relative to one another by guide member 316, such as 90 degrees apart. It is to be understood that guide member 316 may be used with any number of rolling elements 314. Use of guide member 316 is preferred when rolling elements 314 are dimensioned so that each rolling element does not constantly contact two adjacent rolling elements, such as in the arrangements shown in Figs. 16B, 16C, and 16D.

[0032] Although the present invention has been described in considerable detail with reference to certain preferred versions thereof, other versions are possible. Therefore, the scope of the appended claims should not be limited to the description of the preferred versions contained herein.

Claims

1. An apparatus for boring a wellbore (234), the wellbore (234) containing a workstring (230) concentrically positioned therein, the apparatus comprising: a bit body (113) having a first end, an inner cavity (116), and a second end, wherein the first end is connected to the workstring (230), said workstring (230) configured to deliver a rotational force to said bit body (113), wherein the inner cavity (116) contains a profile having a first radial cam surface (117) and wherein the second end includes a working face containing a cutting member; a pilot bit (119) rotatively connected within the inner cavity (116) and extending from the working face, said pilot bit (119) including a first end (121) and a second end (122), wherein the first end (121) has a second radial cam surface (125) operatively configured to cooperate with the first radial cam surface (117) to deliver a hammering force, and wherein the second end (122) of the pilot bit (119) includes an engaging surface (123) configured to engage a formation (240) surrounding the wellbore (234); and wherein the bit body (113) rotates at a higher rotation rate than the pilot bit (119); the apparatus ***characterized by***:
one or more rolling elements (127, 128) disposed between and in contact with the first radial cam surface (117) and the second radial cam surface (125), and *in that* said engaging surface (123) comprises an apex of a conical portion (122), said apex being offset from a center line (124) of the bit body (113).

2. The apparatus of claim 1, wherein said first radial cam surface (117) and said second radial cam surface (125) each have a profile, and at least one of the profiles of said first radial cam surface (117) and said second radial cam surface (125) is an undulating profile.

3. The apparatus of claim 2, *further* ***characterized in that*** a surface (118) of the bit (113) is configured to retain an upper portion (121) of said pilot bit (119) within the inner cavity (116), wherein the workstring (230) is a tubular drill string or a coiled tubing string, and wherein the workstring (230) contains a mud motor (238) for delivering the rotational force.

4. The apparatus of claim 1, wherein each of the rolling elements (127, 128) includes a spherical outer surface.

5. A method of boring a wellbore (234) comprising:

   a) providing a bit apparatus within the wellbore (234), said bit apparatus comprising: a bit body (113) having a first end (4), an inner cavity (116), and a second end, wherein the first end (4) is connected to a workstring (230), said workstring (230) configured to deliver a rotational force to said bit body (113), wherein the inner cavity (116) contains a profile having a first radial cam surface (117), and wherein the second end includes a working face containing a cutting member; a pilot bit (119) rotatively connected within the inner cavity (116) and extending from the working face (23), the pilot bit (119) including a first end (121) and a second end (122), wherein the first end (121) has a second radial cam surface (125) operatively configured to cooperate with the first radial cam surface (117) to deliver a hammering force, and wherein the second end (122) of the pilot bit (119) includes an engaging surface (123) configured to engage a reservoir interface (240) surrounding the wellbore (234); and wherein the bit body (113) rotates at a higher rotation rate than the pilot bit (119); wherein one or more rolling elements (127, 128) are disposed between and in contact with the first radial cam surface (117) and the second radial cam surface (125), and wherein said engaging surface (123) comprises an apex of a conical portion (122), said apex being offset from a center line (124) of the bit body (113);
   b) lowering the bit apparatus into the wellbore (234);
   c) contacting the cutting member of the working face with the reservoir interface (240);
   d) rotating the bit body (113) relative to the pilot bit (119);
   e) engaging the engaging surface (123) of the

pilot bit (119) with the reservoir interface (240) in the wellbore (234);

f) impacting the second radial cam surface (125) with the first radial cam surface (117) through the one or more rolling elements (127, 126) so that the hammering force is delivered to the cutting member and the engaging surface (123) while boring the wellbore (234) with the bit apparatus.

6. The method of claim 5, wherein said first radial cam surface (117) and said second radial cam surface (125) each have a profile, and at least one of the profiles of said first radial cam surface (117) and said second radial cam surface (125) is an undulating profile.

7. The method of claim 6, wherein the workstring (230) contains a mud motor (238) for delivering the rotational force, wherein the workstring (230) is a tubular drill string or a coiled tubing string.

8. The method of claim 5, wherein in step (d), the pilot bit (119) is rotated due to frictional forces associated with the rotation of the bit body (113).

9. The method of claim 5, wherein each of the rolling elements (127, 128) includes a spherical outer surface.

Patentansprüche

1. Eine Vorrichtung zum Bohren eines Bohrlochs (234), wobei das Bohrloch (234) einen konzentrisch darin positionierten Arbeitsstrang (230) enthält, wobei die Vorrichtung Folgendes beinhaltet: einen Meißelkörper (113), der ein erstes Ende, einen inneren Hohlraum (116) und ein zweites Ende aufweist, wobei das erste Ende mit dem Arbeitsstrang (230) verbunden ist, wobei der Arbeitsstrang (230) konfiguriert ist, um eine Drehkraft auf den Meißelkörper (113) zu übertragen, wobei der innere Hohlraum (116) ein Profil enthält, das eine erste radiale Nockenoberfläche (117) aufweist, und wobei das zweite Ende eine Arbeitsfläche umfasst, die ein Schneideteil enthält; einen Pilotmeißel (119), der drehbar innerhalb des inneren Hohlraums (116) verbunden ist und sich von der Arbeitsfläche aus erstreckt, wobei der Pilotmeißel (119) ein erstes Ende (121) und ein zweites Ende (122) umfasst, wobei das erste Ende (121) eine zweite radiale Nockenoberfläche (125) aufweist, die betriebsmäßig konfiguriert ist, um mit der ersten radialen Nockenoberfläche (117) zusammenzuwirken, um eine Schlagkraft zu übertragen, und wobei das zweite Ende (122) des Pilotmeißels (119) eine Eingriffsoberfläche (123) umfasst, die konfiguriert ist, um in eine das Bohrloch (234) umgebende Formation (240) einzugreifen; und wobei sich der Meißelkörper (113) mit einer höheren Drehrate dreht als der Pilotmeißel (119); wobei die Vorrichtung durch Folgendes *gekennzeichnet ist:*
ein oder mehrere Wälzelemente (127, 128), die zwischen der ersten radialen Nockenoberfläche (117) und der zweiten radialen Nockenoberfläche (125) befindlich sind und mit diesen in Kontakt stehen, und *dadurch, dass* die Eingriffsoberfläche (123) eine Spitze eines konischen Abschnitts (122) beinhaltet, wobei die Spitze von einer Mittellinie (124) des Meißelkörpers (113) versetzt ist.

2. Vorrichtung gemäß Anspruch 1, wobei die erste radiale Nockenoberfläche (117) und die zweite radiale Nockenoberfläche (125) jeweils ein Profil aufweisen und mindestens eines der Profile der ersten radialen Nockenoberfläche (117) und der zweiten radialen Nockenoberfläche (125) ein wellenförmiges Profil ist.

3. Vorrichtung gemäß Anspruch 2, *ferner* ***dadurch gekennzeichnet, dass*** eine Oberfläche (118) des Meißels (113) konfiguriert ist, um einen oberen Abschnitt (121) des Pilotmeißels (119) innerhalb des inneren Hohlraums (116) zu halten, wobei der Arbeitsstrang (230) ein rohrförmiger Bohrstrang oder ein gewickelter Rohrstrang ist und wobei der Arbeitsstrang (230) einen Schlammmotor (238) zum Übertragen der Drehkraft enthält.

4. Vorrichtung gemäß Anspruch 1, wobei jedes der Wälzelemente (127, 128) eine sphärische Außenoberfläche umfasst.

5. Ein Verfahren zum Bohren eines Bohrlochs (234), das Folgendes beinhaltet:

a) Bereitstellen einer Meißelvorrichtung innerhalb des Bohrlochs (234), wobei die Meißelvorrichtung Folgendes beinhaltet: einen Meißelkörper (113), der ein erstes Ende (4), einen inneren Hohlraum (116) und ein zweites Ende aufweist, wobei das erste Ende (4) mit einem Arbeitsstrang (230) verbunden ist, wobei der Arbeitsstrang (230) konfiguriert ist, um eine Drehkraft auf den Meißelkörper (113) zu übertragen, wobei der innere Hohlraum (116) ein Profil enthält, das eine erste radiale Nockenoberfläche (117) aufweist, und wobei das zweite Ende eine Arbeitsfläche umfasst, die ein Schneideteil enthält; einen Pilotmeißel (119), der drehbar innerhalb des inneren Hohlraums (116) verbunden ist und sich von der Arbeitsfläche (23) aus erstreckt, wobei der Pilotmeißel (119) ein erstes Ende (121) und ein zweites Ende (122) umfasst, wobei das erste Ende (121) eine zweite radiale Nockenoberfläche (125) aufweist, die betriebsmäßig konfiguriert ist, um mit der ersten radialen Nockenoberfläche (117) zusammenzuwirken, um eine Schlagkraft zu übertragen, und wobei das zweite Ende (122) des Pilotmeißels (119) eine Eingriffsoberfläche (123) umfasst, die konfiguriert ist, um in eine das Bohrloch (234) umgebende Reservoirschnittstelle (240) einzugreifen; und wobei sich der Meißelkörper (113) mit einer höheren Drehrate dreht als der Pilotmeißel (119); wobei ein oder mehrere Wälzelemente (127, 128) zwischen der ersten radiale Nockenoberfläche (117) und der zweiten radiale Nockenoberfläche (125) befindlich sind und mit diesen in Kontakt stehen, und wobei die Eingriffsoberfläche (123) eine Spitze eines konischen Abschnitts (122) beinhaltet, wobei die Spitze von einer Mittellinie (124) des Meißelkörpers (113) versetzt ist;

b) Absenken der Meißelvorrichtung in das Bohrloch (234);

c) In-Kontakt-Bringen des Schneidelements der Arbeitsfläche mit der Reservoirschnittstelle (240);

d) Drehen des Meißelkörpers (113) relativ zu dem Pilotmeißel (119);

e) In-Eingriff-Bringen der Eingriffsoberfläche (123) des Pilotmeißels (119) mit der Reservoirschnittstelle (240) in dem Bohrloch (234);

f) Auftreffen der ersten radialen Nockenoberfläche (117) auf die zweite radiale Nockenoberfläche (125) durch das eine oder die mehreren Wälzelemente (127, 126), sodass die Schlagkraft auf das Schneidelement und die Eingriffsoberfläche (123) übertragen wird, während das Bohrloch (234) mit der Meißelvorrichtung gebohrt wird.

6. Verfahren gemäß Anspruch 5, wobei die erste radiale Nockenoberfläche (117) und die zweite radiale Nockenoberfläche (125) jeweils ein Profil aufweisen und mindestens eines der Profile der ersten radialen Nockenoberfläche (117) und der zweiten radialen Nockenoberfläche (125) ein wellenförmiges Profil ist.

7. Verfahren gemäß Anspruch 6, wobei der Arbeitsstrang (230) einen Schlammmotor (238) zum Übertragen der Drehkraft enthält, wobei der Arbeitsstrang (230) ein rohrförmiger Bohrstrang oder ein gewickelter Rohrstrang ist.

8. Verfahren gemäß Anspruch 5, wobei in Schritt (d) der Pilotmeißel (119) aufgrund von Reibungskräften gedreht wird, die mit der Drehung des Meißelkörpers (113) assoziiert sind.

9. Verfahren gemäß Anspruch 5, wobei jedes der Wälzelemente (127, 128) eine sphärische Außenoberfläche umfasst.

Revendications

1. Un appareil pour forer un puits de forage (234), le puits de forage (234) contenant une colonne de travail (230) positionnée concentriquement dans celui-ci, l'appareil comprenant : un corps de trépan (113) ayant une première extrémité, une cavité interne (116), et une deuxième extrémité, la première extrémité étant raccordée à la colonne de travail (230), ladite colonne de travail (230) étant configurée pour administrer une force rotationnelle audit corps de trépan (113), la cavité interne (116) contenant un profil ayant une première surface de came radiale (117) et la deuxième extrémité incluant une face de travail contenant un organe de coupe ; un trépan pilote (119) raccordé de façon rotative au sein de la cavité interne (116) et s'étendant à partir de la face de travail, ledit trépan pilote (119) incluant une première extrémité (121) et une deuxième extrémité (122), la première extrémité (121) ayant une deuxième surface de came radiale (125) configurée de façon opérationnelle pour coopérer avec la première surface de came radiale (117) afin d'administrer une force de martèlement, et la deuxième extrémité (122) du trépan pilote (119) incluant une surface de mise en prise (123) configurée pour se mettre en prise avec une formation (240) entourant le puits de forage (234) ; et le corps de trépan (113) tournant à une vitesse de rotation plus élevée que le trépan pilote (119) ; l'appareil *étant* ***caractérisé par :***

un ou plusieurs éléments de roulement (127, 128) disposés entre et en contact avec la première surface de came radiale (117) et la deuxième surface de came radiale (125), et *en ce que* ladite surface de mise en prise (123) comprend un apex d'une portion conique (122), ledit apex étant décalé par rapport à une ligne centrale (124) du corps de trépan (113).

2. L'appareil de la revendication 1, dans lequel ladite première surface de came radiale (117) et ladite deuxième surface de came radiale (125) ont chacune un profil, et au moins l'un des profils de ladite première surface de came radiale (117) et de ladite deuxième surface de came radiale (125) est un profil ondulé.

3. L'appareil de la revendication 2, *caractérisé en outre en ce qu'*une surface (118) du trépan (113) est configurée pour retenir une portion supérieure (121) dudit trépan pilote (119) au sein de la cavité interne (116), dans lequel la colonne de travail (230) est un train de tiges tubulaire ou un train de tubage spiralé, et dans lequel la colonne de travail (230) contient un moteur à boue (238) pour administrer la force rotationnelle.

4. L'appareil de la revendication 1, dans lequel chacun des éléments de roulement (127, 128) inclut une surface externe sphérique.

5. Un procédé de forage d'un puits de forage (234) comprenant :

a) fournir un appareil trépan au sein du puits de forage (234), ledit appareil trépan comprenant : un corps de trépan (113) ayant une première extrémité (4), une cavité interne (116), et une deuxième extrémité, la première extrémité (4) étant raccordée à une colonne de travail (230), ladite colonne de travail (230) étant configurée pour administrer une force rotationnelle audit corps de trépan (113), la cavité interne (116) contenant un profil ayant une première surface de came radiale (117), et la deuxième extrémité incluant une face de travail contenant un organe de coupe ; un trépan pilote (119) raccordé de façon rotative au sein de la cavité interne (116) et s'étendant à partir de la face de travail (23), le trépan pilote (119) incluant une première extrémité (121) et une deuxième extrémité (122), la première extrémité (121) ayant une deuxième surface de came radiale (125) configurée de façon opérationnelle pour coopérer avec la première surface de came radiale (117) afin d'administrer une force de martèlement, et la deuxième extrémité (122) du trépan pilote (119) incluant une surface de mise en prise (123) configurée pour se mettre en prise avec une interface de réservoir (240) entourant le puits de forage (234) ; et le corps de trépan (113) tournant à une vitesse de rotation plus élevée que celle du trépan pilote (119) ; dans lequel un ou plusieurs éléments de roulement (127, 128) sont disposés entre et en contact avec la première surface de came radiale (117) et la deuxième surface de came radiale (125), et ladite surface de mise en prise (123) comprenant un apex d'une portion conique (122), ledit apex étant décalé par rapport à une ligne centrale (124) du corps de trépan (113) ;
b) faire descendre l'appareil trépan dans le puits de forage (234) ;
c) mettre en contact l'organe de coupe de la face de travail avec l'interface de réservoir (240) ;
d) faire tourner le corps de trépan (113) relativement au trépan pilote (119) ;
e) mettre en prise la surface de mise en prise (123) du trépan pilote (119) avec l'interface de réservoir (240) dans le puits de forage (234) ;
f) percuter la deuxième surface de came radiale (125) avec la première surface de came radiale (117) par l'intermédiaire des un ou plusieurs éléments de roulement (127, 126) de sorte que la force de martèlement est administrée à l'organe de coupe et à la surface de mise en prise (123) tout en forant le puits de forage (234) avec l'appareil trépan.

6. Le procédé de la revendication 5, dans lequel ladite première surface de came radiale (117) et ladite deuxième surface de came radiale (125) ont chacune un profil, et au moins l'un des profils de ladite première surface de came radiale (117) et de ladite deuxième surface de came radiale (125) est un profil ondulé.

7. Le procédé de la revendication 6, dans lequel la colonne de travail (230) contient un moteur à boue (238) pour administrer la force rotationnelle, la colonne de travail (230) étant un train de tiges tubulaire ou un train de tubage spiralé.

8. Le procédé de la revendication 5, dans lequel dans l'étape (d), le trépan pilote (119) est soumis à une rotation en raison de forces de frottement associées à la rotation du corps de trépan (113).

9. Le procédé de la revendication 5, dans lequel chacun des éléments de roulement (127, 128) inclut une surface externe sphérique.

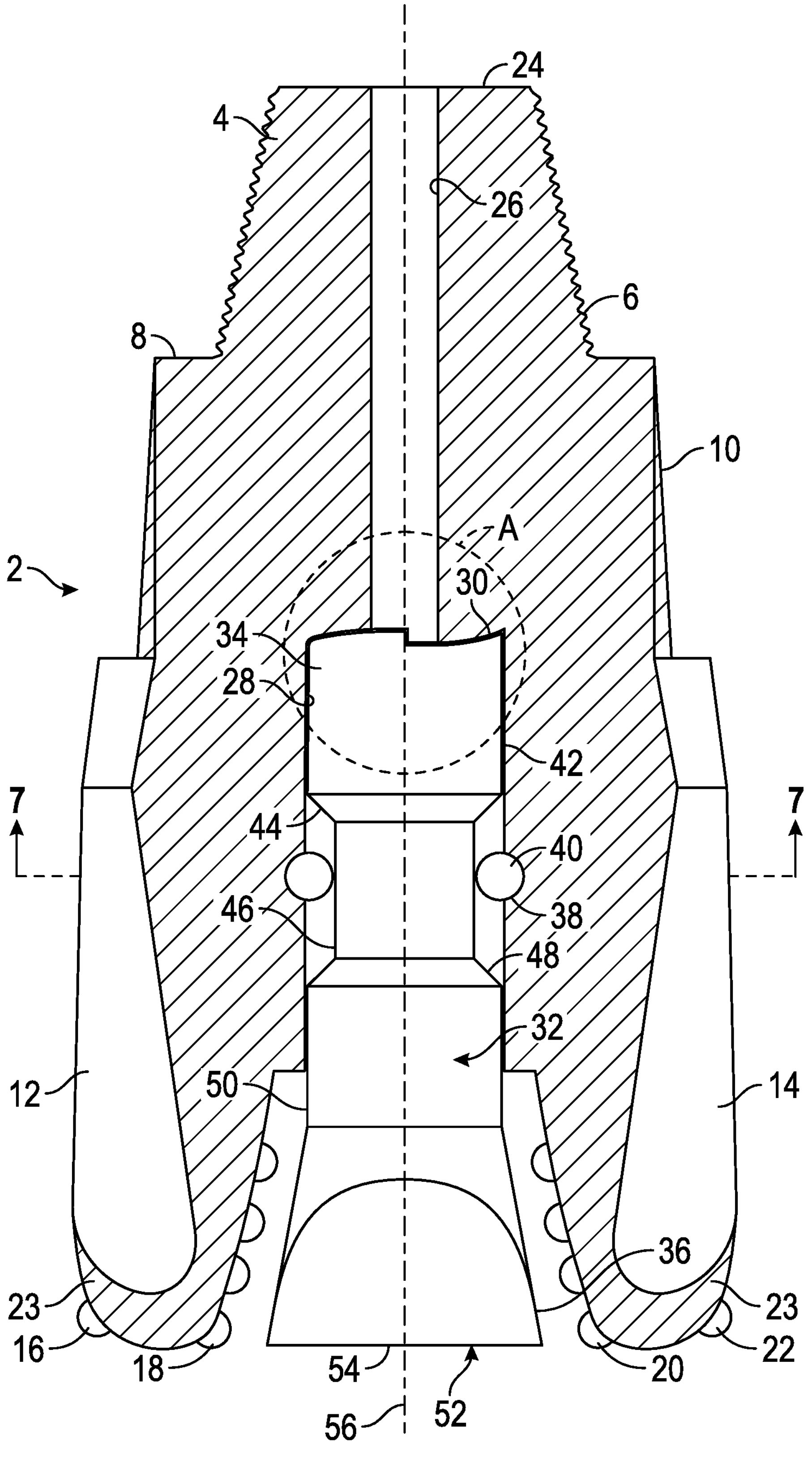
24
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FIG. 1

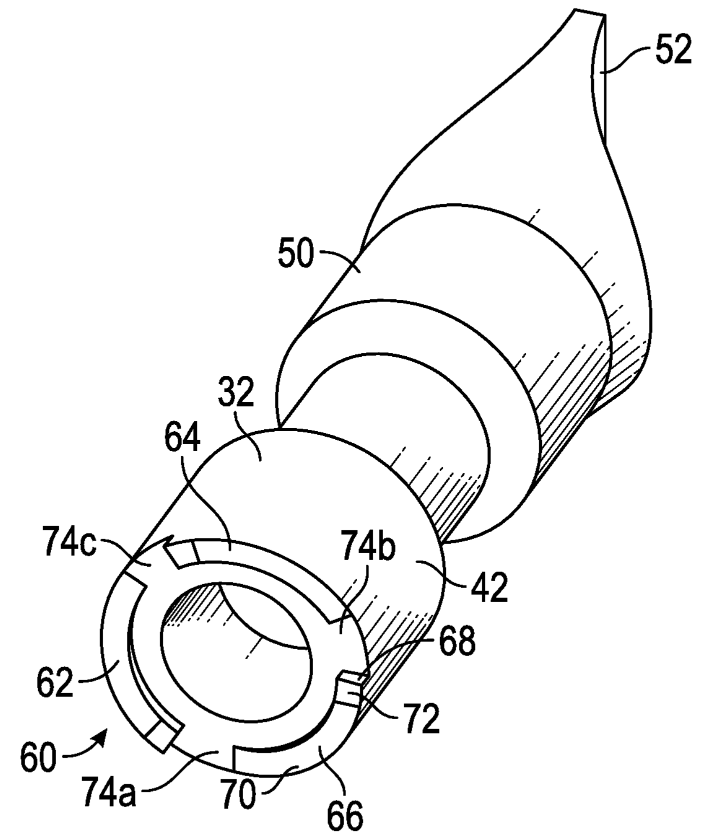

FIG. 2

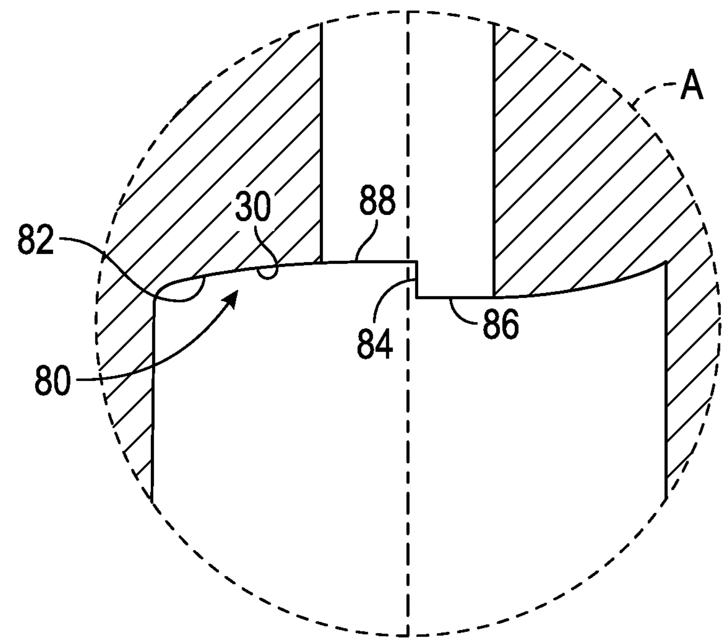

FIG. 3

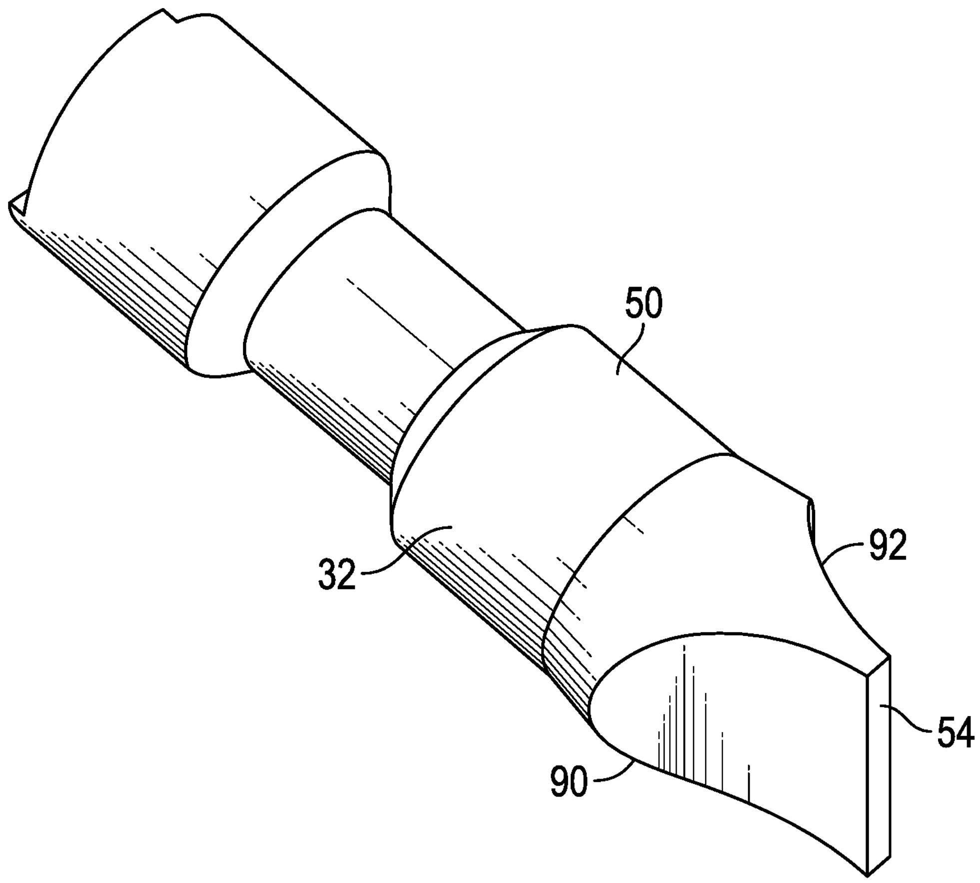

FIG. 4

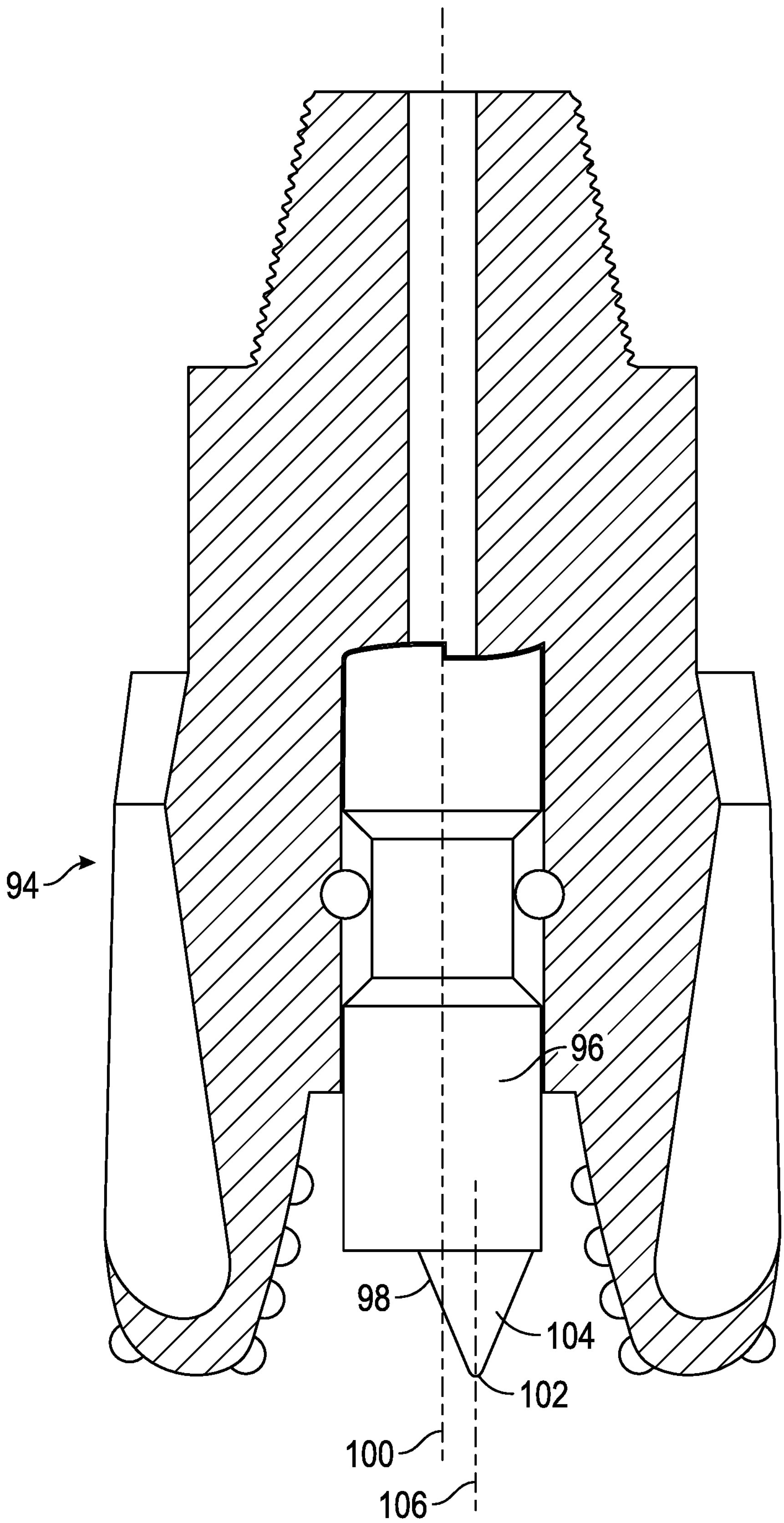

FIG. 5

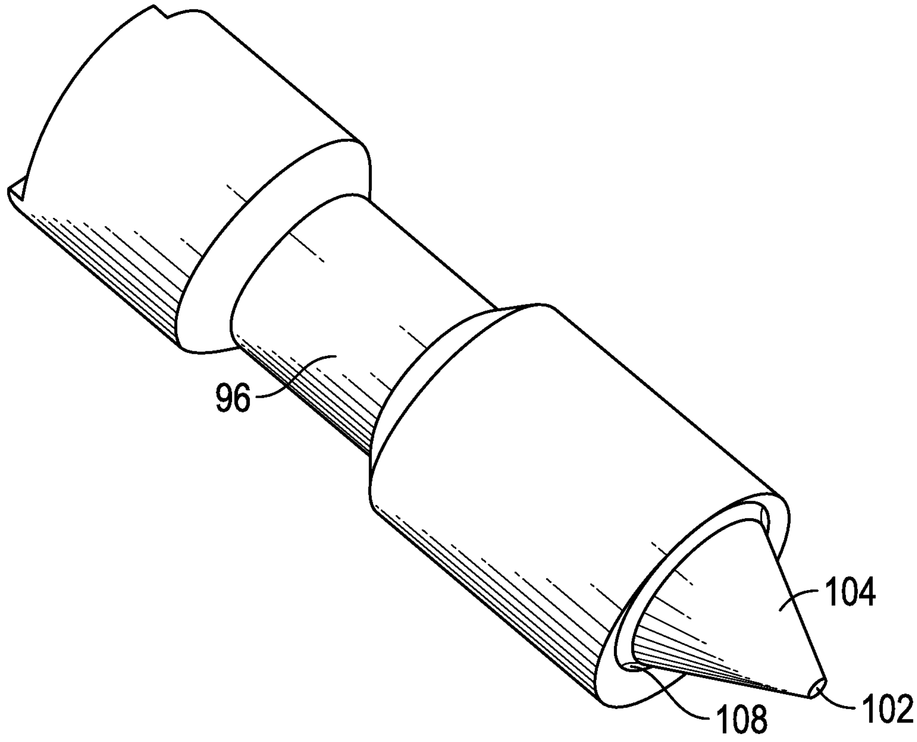

FIG. 6

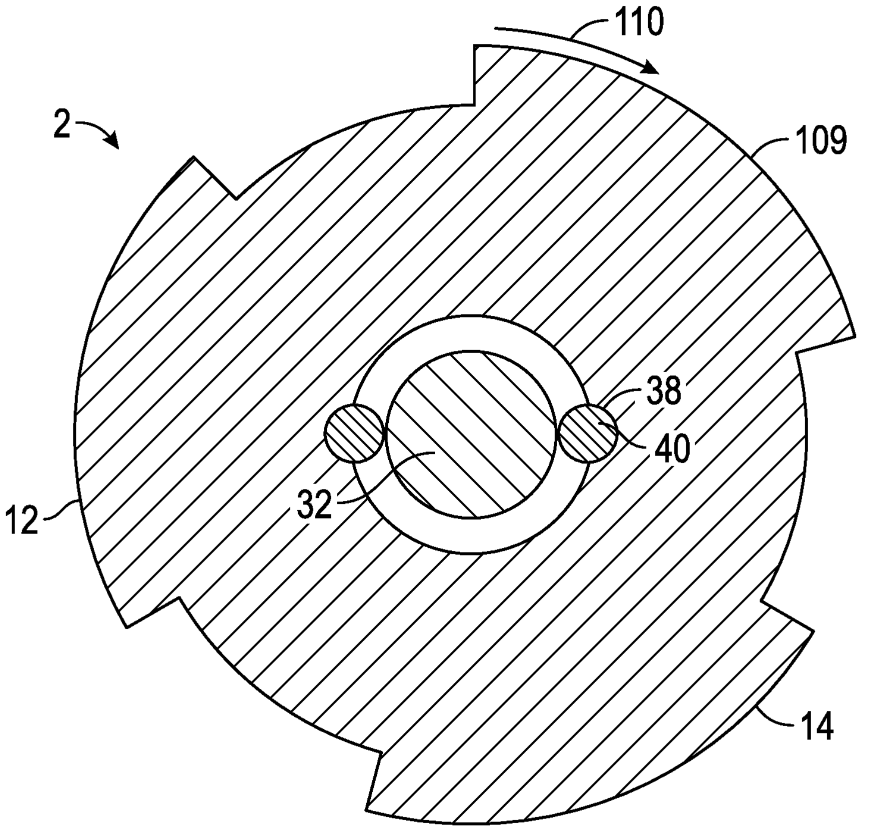

FIG. 7

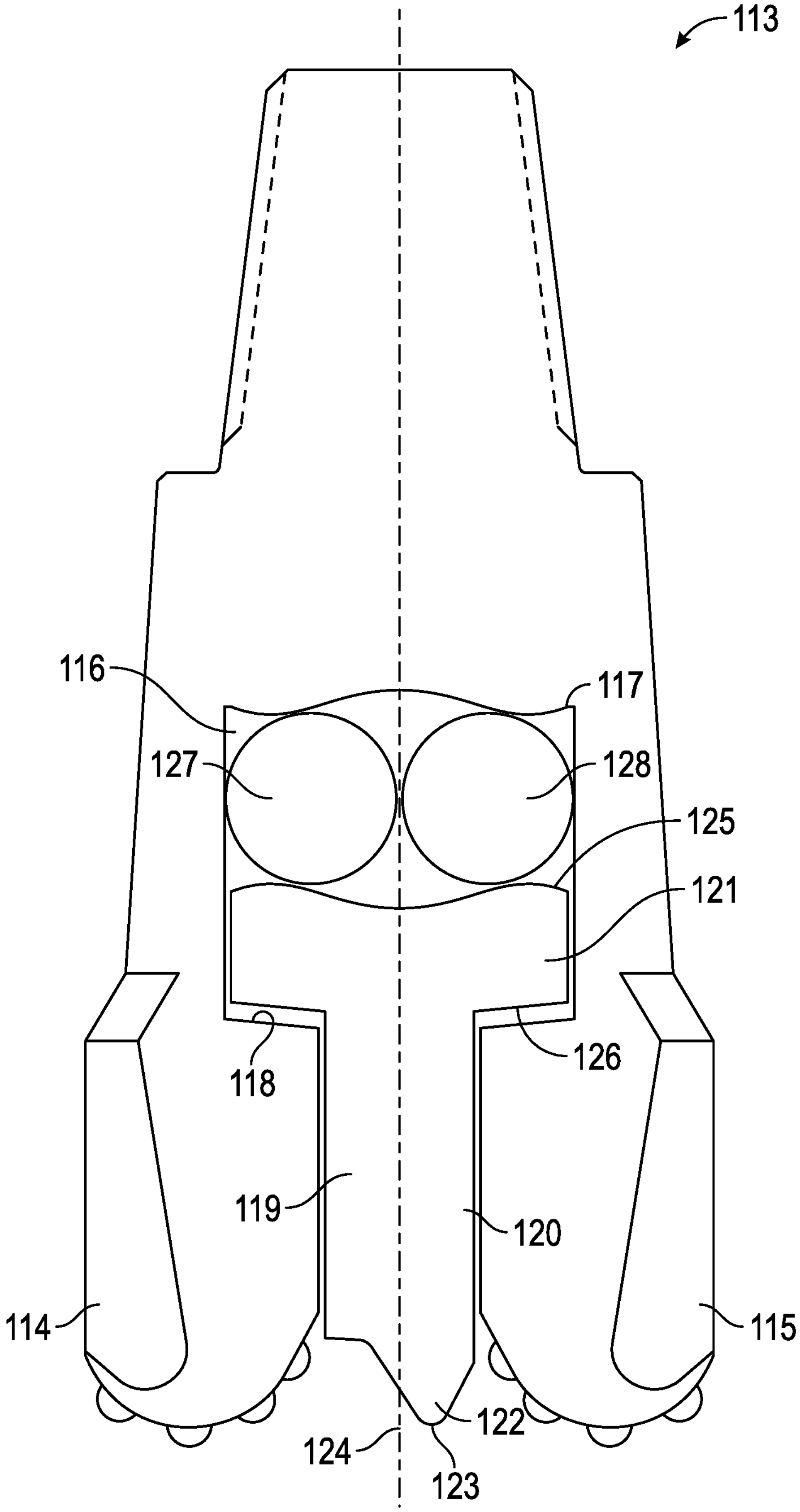

FIG. 8

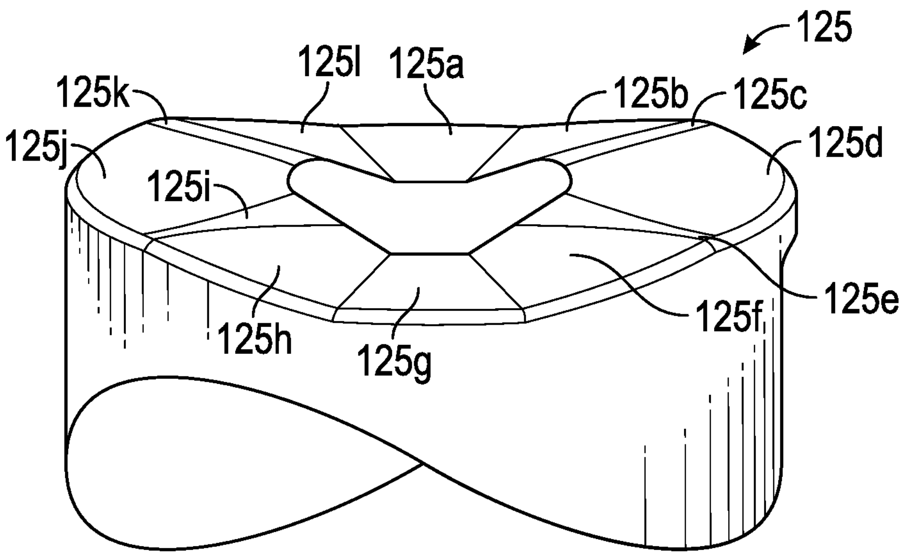

FIG. 9A

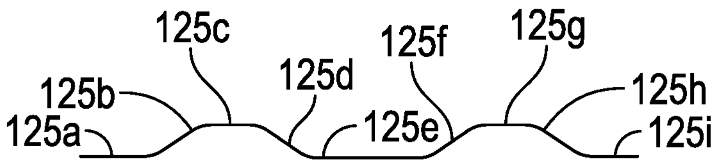

FIG. 9B

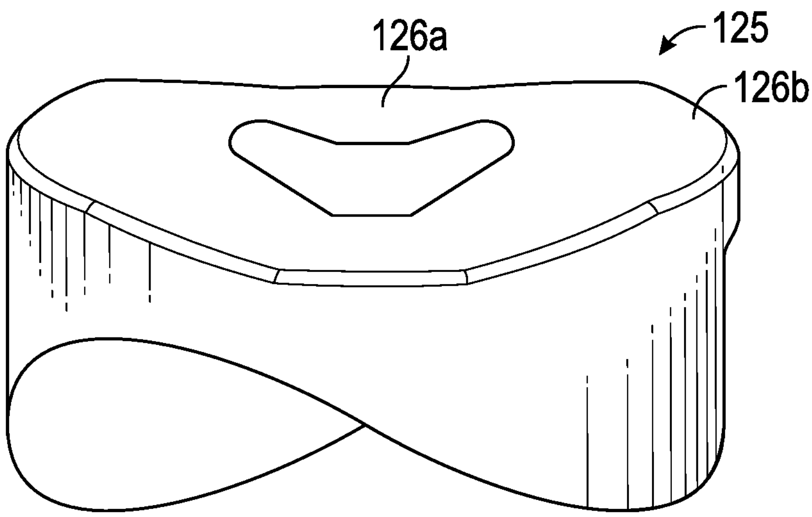

FIG. 9C

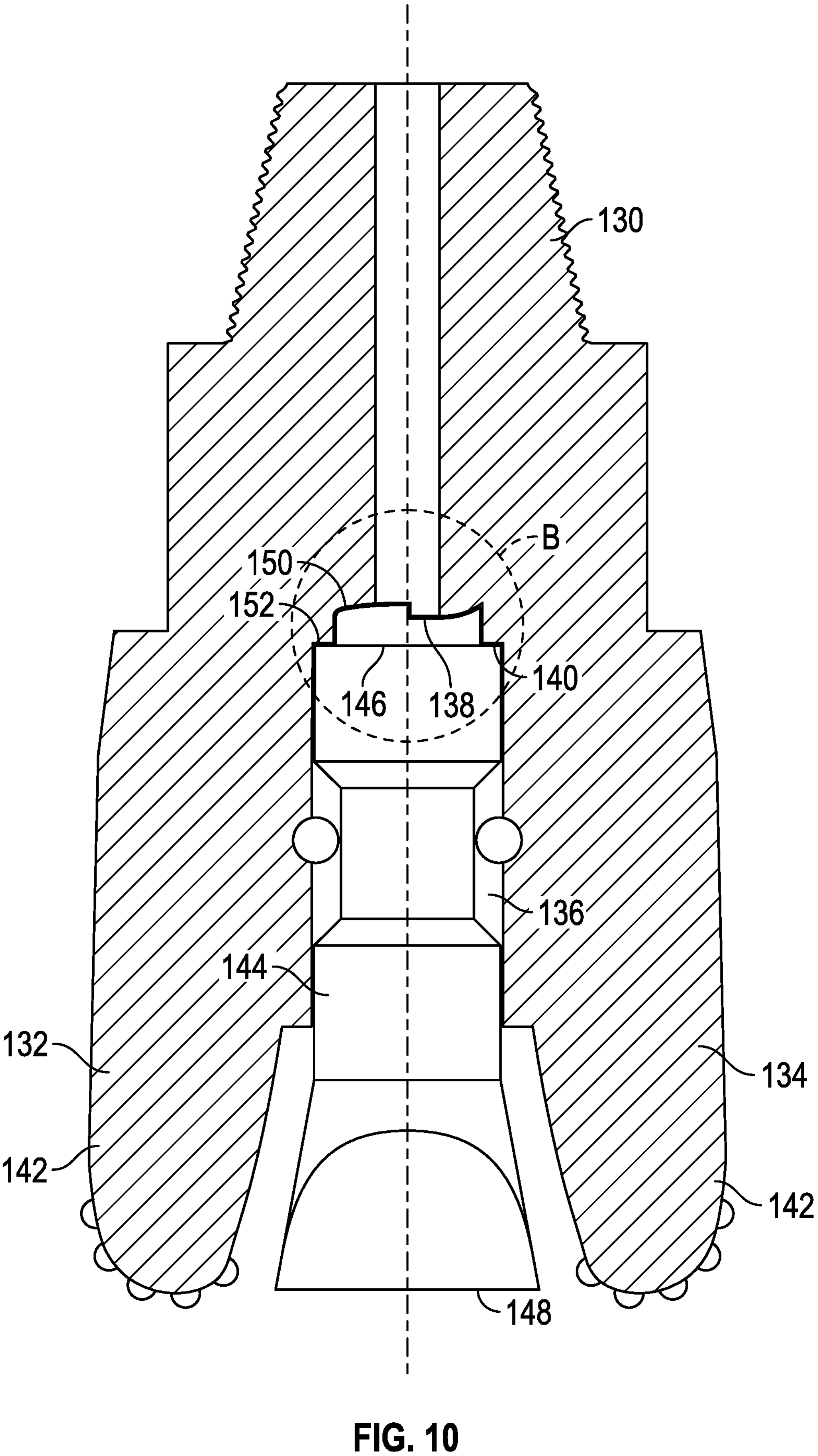

FIG. 10

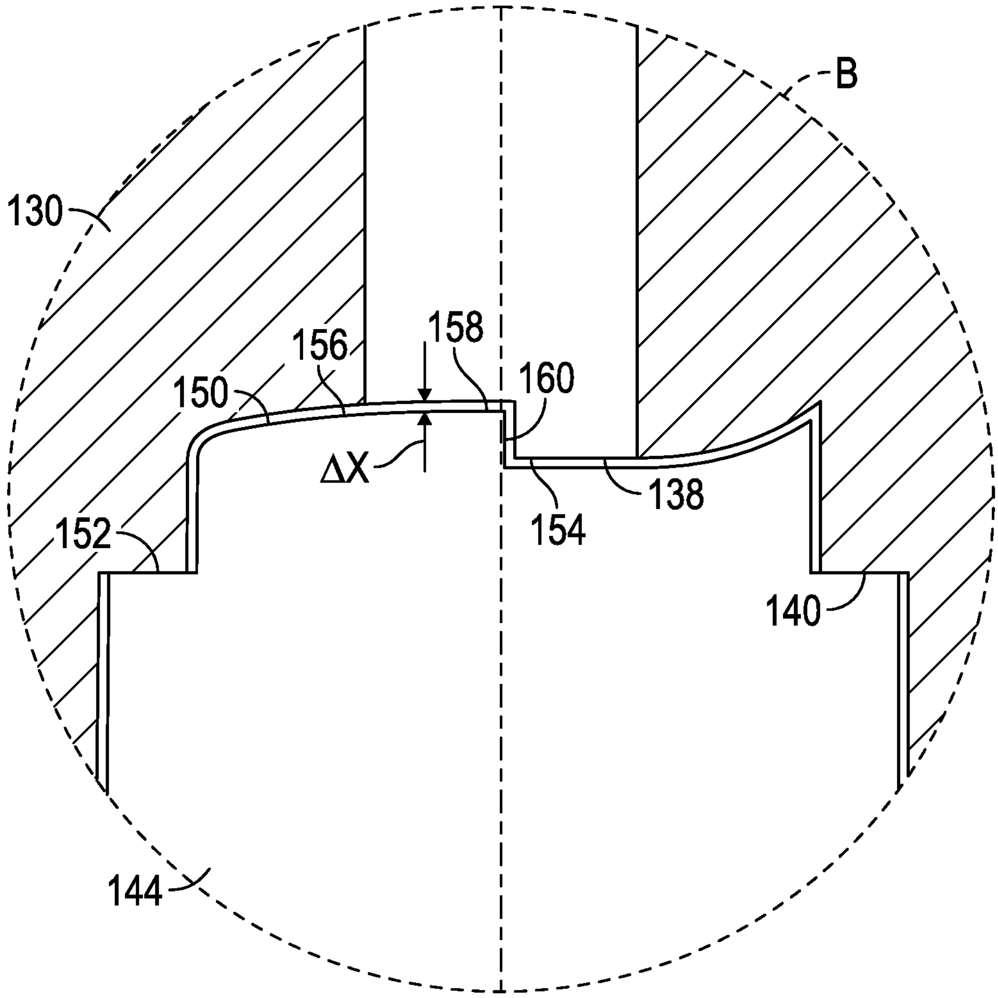

FIG. 11

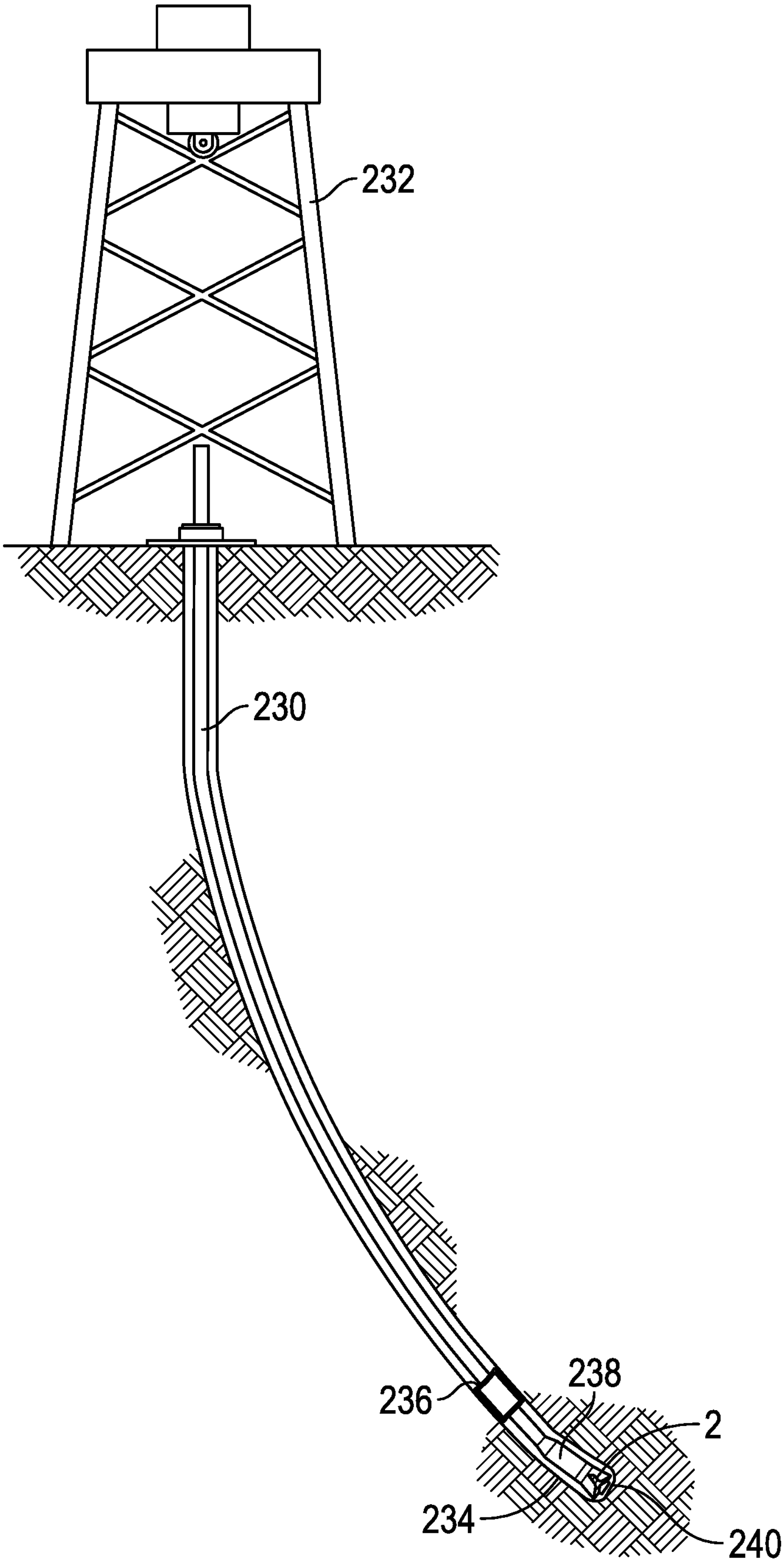

FIG. 12

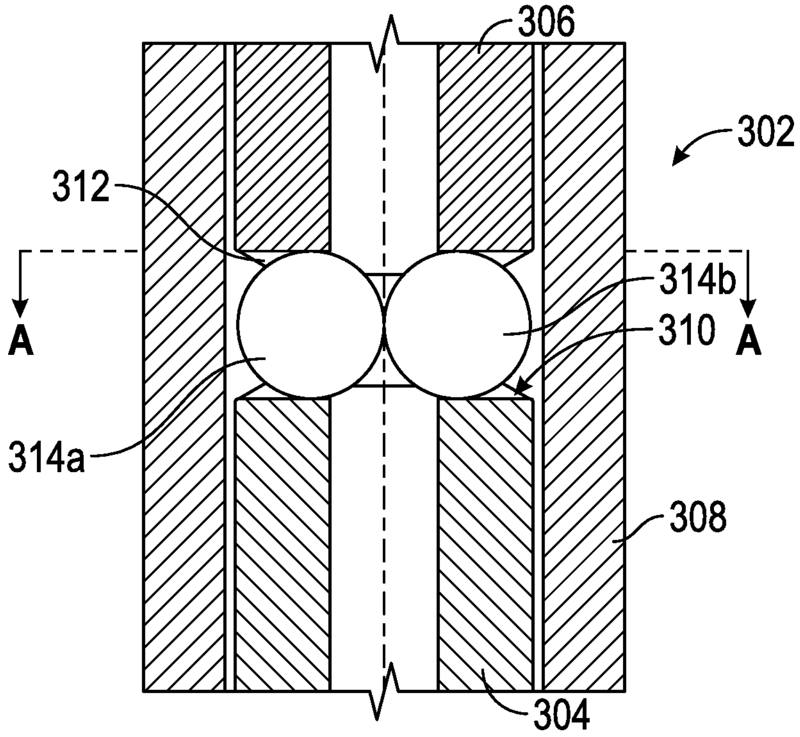

FIG. 13

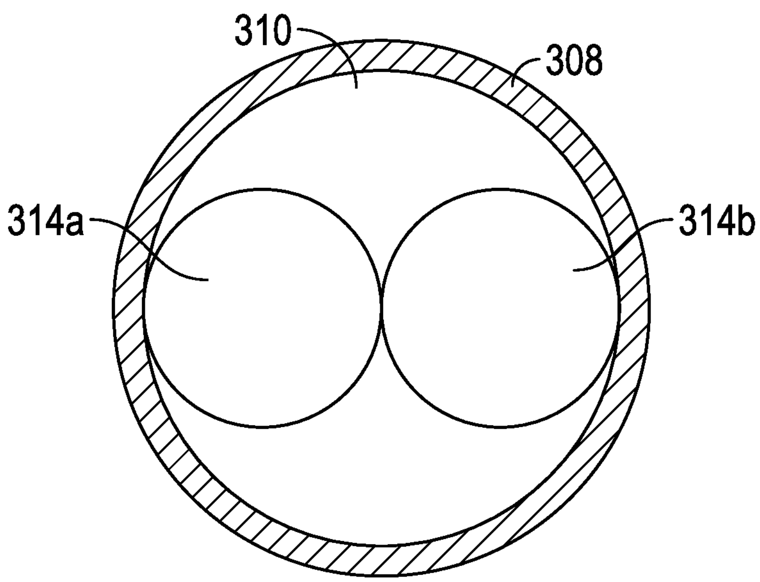

FIG. 14A

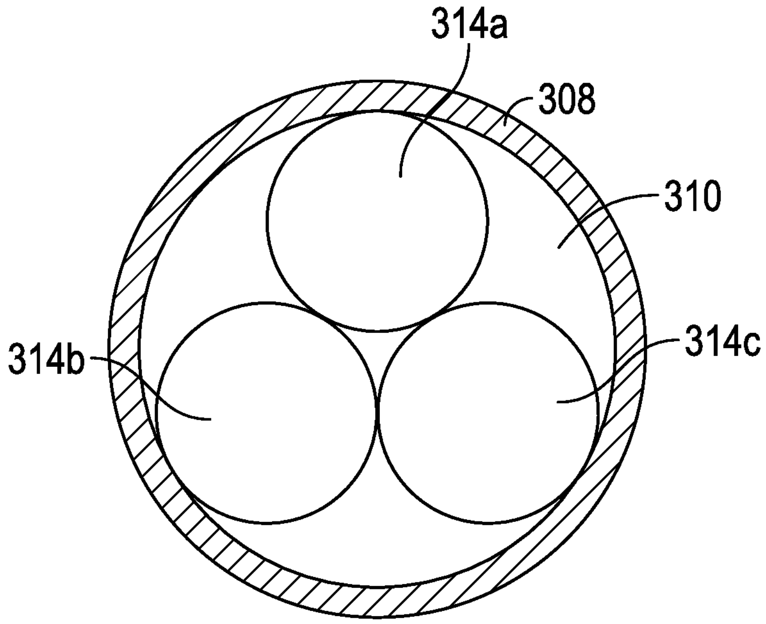

FIG. 14B

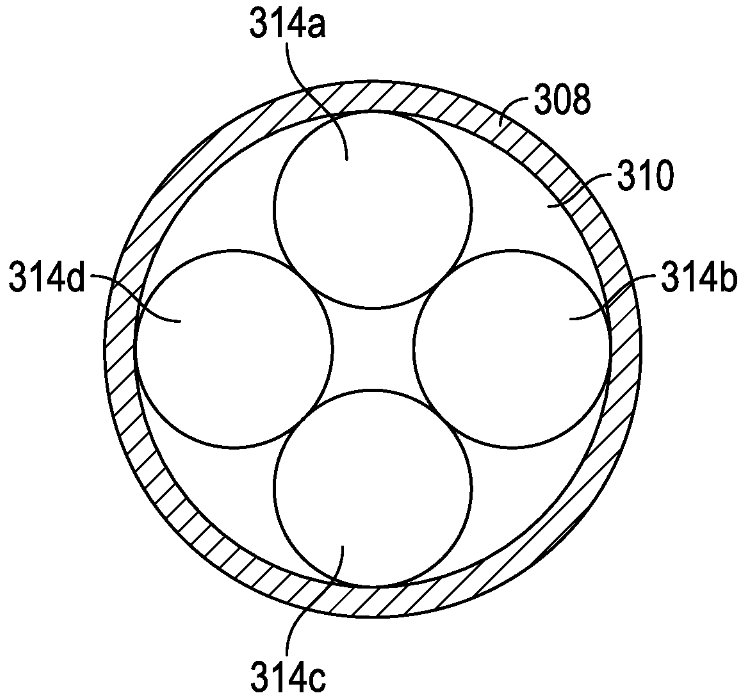

FIG. 14C

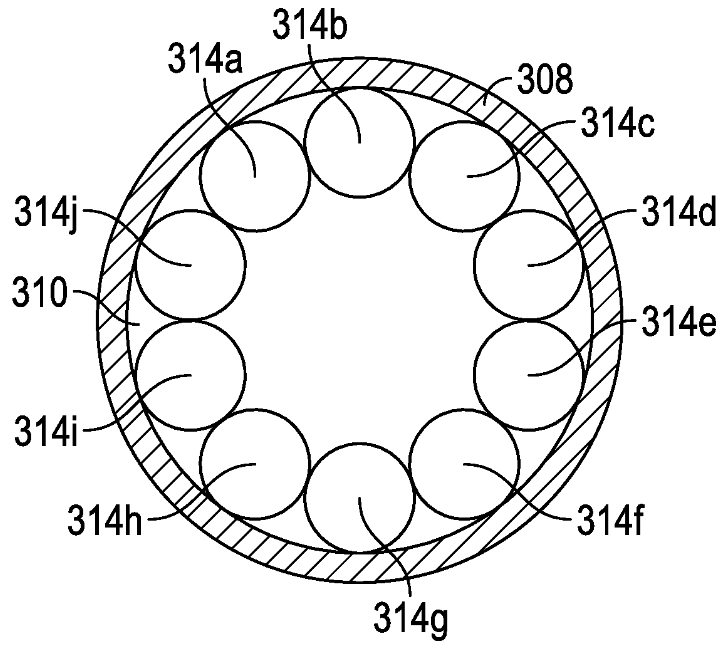

FIG. 14D

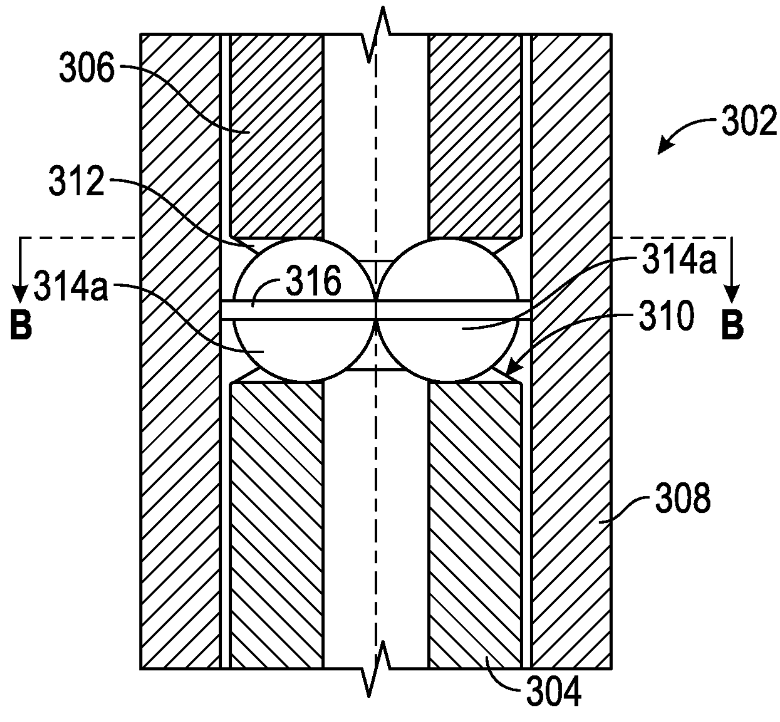

FIG. 15

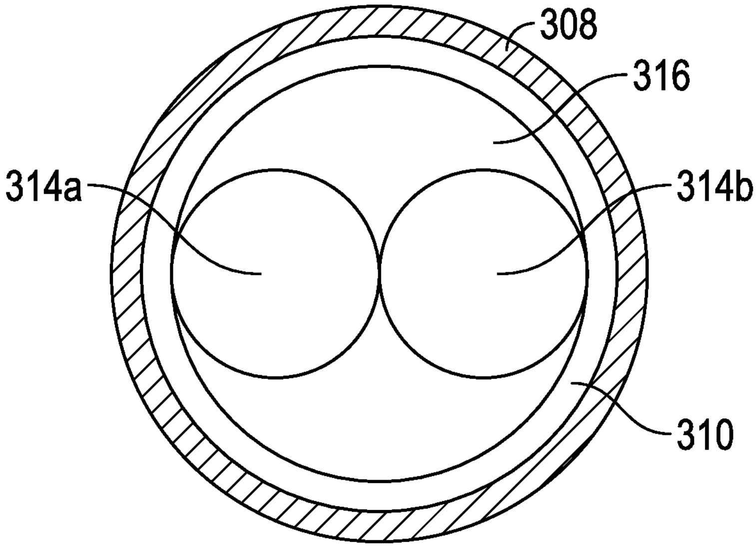

FIG. 16A

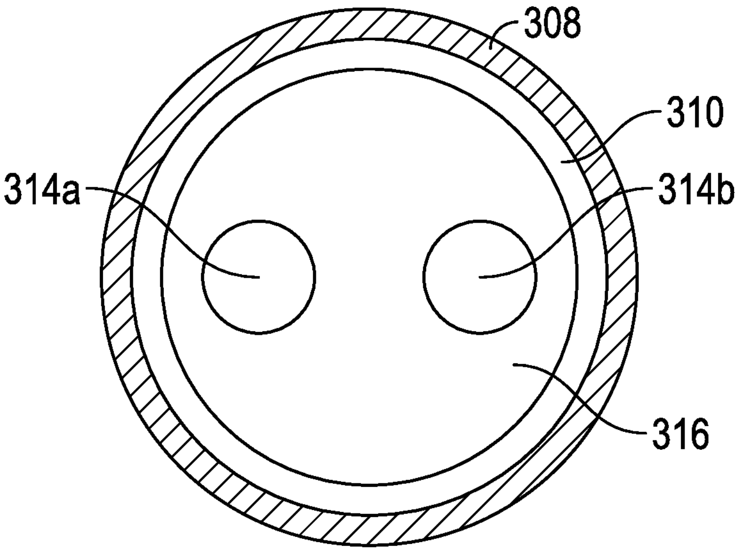

FIG. 16B

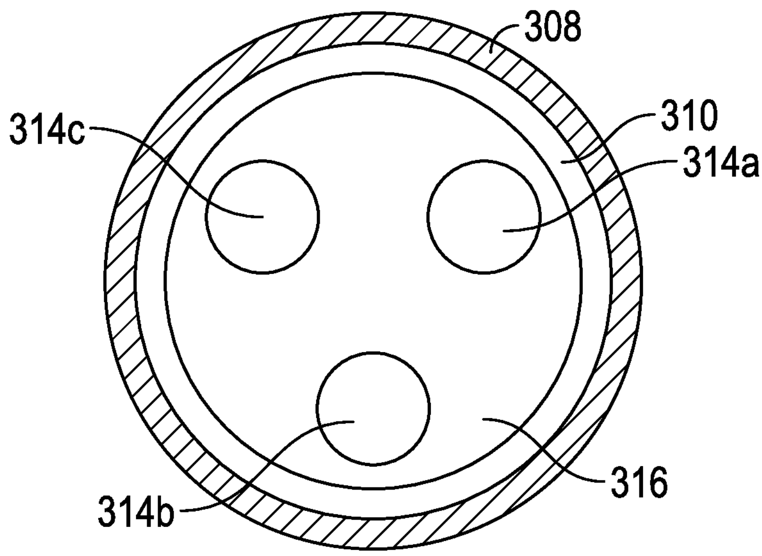

FIG. 16C

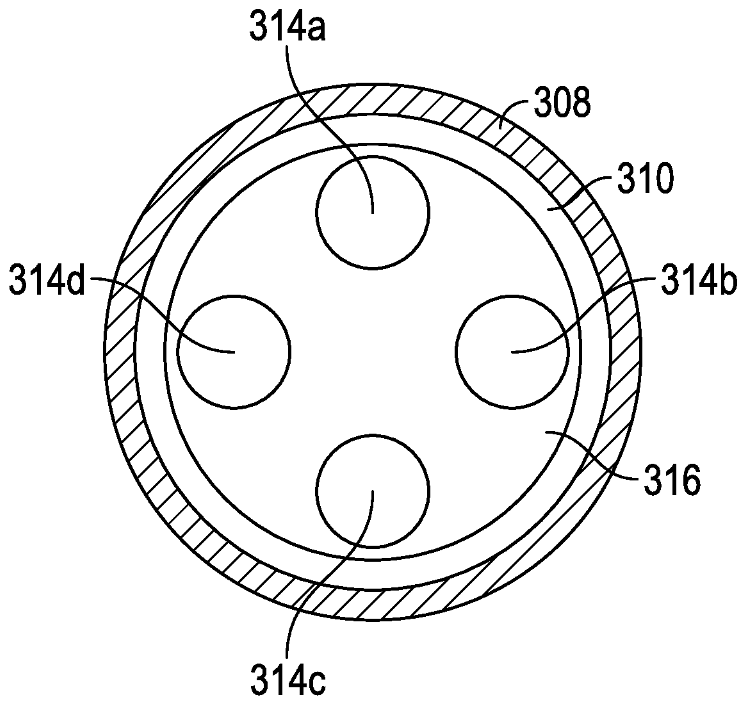

FIG. 16D

REFERENCES CITED IN THE DESCRIPTION

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